General Notes.

GEOLOGY AND PALEONTOLOGY.

On the Crystalline Schists and Their Relation to the Mesozoic Rocks in the Lepontine Alps.[1]—At the close of the year 1888 Prof. T. G. Bonney read before the London Geological Society a paper in which he maintained that these rocks could be arranged in certain fairly definite groups, which exhibited a stratigraphical succession. On this communication only two criticisms of importance were offered. Of these one expressed a doubt as to the value of the method which Mr. Bonney had adopted in his work; the other affirmed that certain schists, regarded by Mr. Bonney as members of a very ancient series, probably Archean, had been demonstrated by the presence of Mesozoic fossils to be of the latter age; or, in other words, that in the Alps ordinary sediments deposited in the Jurassic epoch had been subsequently converted into true crystalline schists, a result of metamorphic action, which he had implicitly affirmed to be incredible. Early in 1890 Prof. Bonney replied to these criticisms in the following language:

"The former criticism, which amounted to an assertion that the general succession of the Alpine rocks could only be ascertained by very detailed mapping, in my opinion indicated an imperfect knowledge of the subject, while it was scientifically unsound and historically incorrect. It indicated an imperfect knowledge because, as a matter of fact, a considerable part of the Alps has already been mapped, not by irresponsible amateurs but by official surveyors, and it was with the interpretation of these maps that I was largely concerned; and because it assumed that an impossibility could be performed. As I have had the honor to fill the same position in the Alpine Club that I have done in this society, I may affirm, without fear of contradiction, that a very elaborate petrographical mapping of the Alps is impossible, for the most painstaking and conscientious of surveyors must assume much that is incapable of demonstration. A very large part of the whole area is concealed by snow, glaziers, *débris*, pasture, forest; and some

[1] On the Crystalline Schists and Their Relation to the Mesozoic Rocks in the Lepontine Alps. By T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., Professor of Geology in University College, London, and Fellow of St. John's College, Cambridge.

one of these obstacles very frequently interferes, in a most provoking way, just at the most critical point. Further, no small amount of the rock which is visible can only be regarded from a distance. Many a cliff, many a ridge, is inaccessible, and the examination, even of every point which it would be possible to reach, would require the expenditure of such an amount of time that I am certain it never has been, and believe that it never will be done.

"But further, the criticism, in my opinion, was scientifically unsound and historically unjustifiable,—scientifically unsound because very commonly the most important problems which are presented by the crystalline rocks receive a decisive answer from one or two sections only. I have not the slightest desire to undervalue elaborate mapping, but we must be careful not to treat it as a fetish, as though it were the only means appointed for the discovery of geological truth. Its results more commonly are the removal of minor difficulties in a conclusion already attained, and the disclosure of the precise mode in which certain effects have been produced. The criticism was historically unjustifiable because, so far as my knowledge goes, it is a fact that in regard to difficult petrological questions infallibility has not been found to reside with the makers of geological maps.

"My work, both in the Alps and in other regions, which has been carried on with a definite object and a fairly clear idea as to the needful evidence, has led me to the following conclusions, which, though they have been already expressed, I will venture to repeat for the information of the reader:

"1. That a group of truly crystalline schists is always more ancient than any rock to which, on the evidence of fossils, a date can be assigned.

"2. That many such groups can be proved to be older than any Paleozoic rock.

"3. That though crystalline schists have often been claimed as metamorphosed sedimentary strata of Paleozoic or Mesozoic, if not of Tertiary age, the evidence in support of this claim has hitherto always broken down on careful examination, and in not a few instances has proved hardly worthy of the name.

"4. That in certain cases structures exist in the crystalline schists which must be indicative of sedimentation, and that in not a few instances a sequence can be detected which must be due to successive deposition. Great as modifications resulting from subsequent pressure very frequently are, these may often be separated, and the earlier record as in the case of a palimpset be deciphered.

"In the Alps there exists, as has frequently been pointed out by those who have preceded me, a great group of crystalline schists, the bulk of which must be metamorphosed sedimentary deposits. This group can be traced, practically without a break, from one end of the chain to the other. These schists certainly overlie, sometimes it would seem unconformably, another series of gneisses and schists, generally coarser in texture. These seem to be divisible into two groups, differing in lithological characters, of which the upper, though sometimes well developed, is not seldom wanting; so that instead of the gradual transition from it to the first-named group, which can sometimes be observed, we find the latter resting with marked discordance upon some part of the lower series.

"The oldest unaltered rocks in the Alps generally belong to the lowest part of the Mesozoic system, Jurassic or Triassic (possibly sometimes Permian), but in certain districts not inconsiderable deposits of Carboniferous age (quite disconnected from the last named) occur, and in the northeastern Alps Paleozoic rocks of yet earlier date have been identified. All these are practically unaltered. An exceptionally wide experience enables me to affirm, without fear of contradiction, that, in case of any large mass which would be referred without hesitation to the Jurassic, Triassic, or Carboniferous group, there will not be found, however great may have been the mechanical disturbances which it has undergone, any transition exhibited by it into one of the normal gneisses or schists; at most a microfoliation has been developed or a superficial resemblance set up. The crystalline schists also do not exhibit, as a rule, any tendency to pass into ordinary sedimentary rocks. Appearances suggestive of this transition are found on closer examination to be due either to pulverization of the rocks by pressure, or to the inclusion of a later series by folding or faulting.

"But while there can be no doubt of the general truth of this statement, it has recently been asserted that in certain districts of the Alps there is a passage from Jurassic rocks into truly crystalline limestones, while in others fossils of that age occur together with garnet, mica, and minerals resembling staurolite, in schists which cannot be distinguished from certain members of the above-named group. If this assertion be correct, it must follow (1) that the Alps exhibit true schists which are metamorphosed sediments of Mesozoic age, and (2) that, inasmuch as these are undistinguishable from schists which by stratigraphical evidence can be proved to be very much older than any Mesozoic rocks, a schist, like a granite or a dolerite, might belong to almost any geological epoch.

"This last opinion can claim the sanction of antiquity and the authority of weighty names, but the progress of investigation had largely diminished the number of its supporters, when it seemed to receive a new life from a recognition of the amazing effects of mechanical forces in modifying rock-structures, and from the above-named discoveries in the Alps. Specimens illustrative of the latter were exhibited at the International Congress in September, 1888. Those supposed to indicate the passage of an ordinary Jurassic limestone into a crystalline marble (from a district which I had already visited) did not appear to me convincing. But those exhibiting fossils in a rock resembling a true schist were certainly very remarkable, and seemed to afford considerable support to the opinion mentioned above. I was, not, however, convinced by them, because, though I had not examined the two localities in which the supposed 'fossiliferous schists' occurred, I was fairly acquainted with the geology of the district, and had been very near, in one case within less than a mile, to each locality. I had also examined rocks identical, as I believed, with those in which the fossils occurred. The knowledge thus obtained, notwithstanding the apparent evidence of the specimens exhibited, suggested to my mind the possibility of a mistake, and a doubt whether the identity of the fossiliferous rock with the true schists of the district was not more apparent than real. Still, so remarkable were the specimens, so great was the weight of authority, that when these cases were quoted against me in the discussion on my paper, I departed from that which has become almost a rule with me, viz., to pay no regard to criticisms founded on second-hand information —and stated that I accepted the challenge."

During the summer of 1889 Prof. Bonney resumed his study of the district under discussion in company with Mr. J. Eccles, F.G.S. The results of their investigations fully confirm the conclusions Prof. Bonney had stated the year before.

The Australian Cenozoic Fauna.—Mr. J. W. Gregory says that this fauna seems to be composed of two constituents; about a third are species of the ordinary Palæarctic Upper Cretaceous genera; these seem to have migrated southwards and become mingled on their journey with a fauna that agrees most closely with that of the Eocenes of India and Malaysia. No abyssal types were picked up on the march, nor do any of the species retain any trace of the influence of a deep-sea habitat. Hence the route may have followed the coasts of Asia and Malaysia, or the line may have lain across what is now

occupied by the deep abysses of the Indian Ocean; but if so it must have occurred before its bed had subsided to anything like its present depth. (*Geol. Mag.*, Nov., 1890.)

Fossil Fishes of the Cretaceous Formations of Scandinavia.[2]—This is a quarto publication of the Royal Dublin Society, and forms part of Vol. IV. (Series II.) of their Transactions. As the author had placed at his disposal the collections at Stockholm and Copenhagen, and furthermore had the opportunity of comparing the Scandinavian specimens with those in the British Museum, his memoir is a valuable contribution to science.

The classification is based on that of Mr. A. Smith Woodward, and with few exceptions, the most important family represented is the Lamnidæ.

A general view of the ichthyic fauna of the Swedish chalk is given as follows:

"It has shown, generally, a closer relationship to the Cretaceous fauna of the north of Europe, as represented in the English and French chalk, than to the more highly specialized fauna of Asia Minor; but it does not afford representatives of several of the Physostomous Teleostomi, such as Ichthyodectes, Protosphyræna, and Pachyrhizodus, which occur in the English chalk, and have been found in the Upper Cretaceous rocks of North America. A few teeth occur in the Swedish chalk which are referred to Enchodus. Examples of a large species of Dercetis occur, and some fragmentary remains which are probably Clupean. The highly specialized forms, such as Chirothrix, Rhinellus, etc., found in the Lebanon chalk, do not occur in the chalk of Sweden. Among the Acanthopterygian Teleosteans the most important are the remains of Beryx and Hoplopteryx.

"The great majority of the fish remains are Selachian, and comprise no fewer than twenty-four species. Three species, viz., *Carcharodon rondeletii* (M. & H.), *Otodus obliquus* (Ag.), and *Odontaspis acutissimus* (Ag.) are usually regarded and known as indicating a Tertiary fauna; but in the Scandinavian chalk they have been found in association with many undoubted Cretaceous forms in the Faxe limestone, and so appear to prove that these species were in existence before the advent of the deposition of the Tertiary strata. The Tectospondylic sharks are represented by two species of Ptychodus and indefinable teeth of Myliobatis. The Asterospondylic sharks occur in very large numbers,

[2] On the Fossil Fishes of the Cretaceous Formations of Scandinavia. By James W. Davis, F.G.S., F.L.S., F.S.A., etc. Plates XXXVIII. to XLVI. Trans. Royal Dublin Soc., Vol. IV., Series II.

and represent several genera. Beautifully preserved specimens of Notidanus, Scapanorhyncus (Rhinognathus), Odontaspis, Oxyrhina, Otodus, Lamna, and Corax are abundant, and have a wide vertical range. The character and extent of the Selachian fauna indicate conditions very similar to those accompanying the deposition of the English and French chalk, and that of Central Europe generally, whilst it affords comparatively few data for comparison with that of Lebanon."

The Surface Geology of Alaska.—I. C. Russell's paper on the surface geology of Alaska contains some interesting facts on the glaciation of that region. He agrees with Dauron and McConnell that there is a great area to the north of the Cordilleran glacier which was not occupied by ice during the Plistocene. Of living glaciers those on the north side of the Coast Range are very much smaller than, and do not descend nearly so far as, the glaciers on the south side of the same range. Closely related to the distribution of the glaciers are certain climatic phenomena.

In the Yukon region the winters are long and extremely cold, but the snowfall is not great. The summers, though short, are pleasant, and hot enough to melt the winter's snows. On the southern coast the winters are not severe, but the snowfall is heavy on the mountains, and the summers are cloudy and hot, with much fog.

These observations show that abundant precipitation, accompanied by a low mean annual temperature (due especially to a cool and cloudy summer) has resulted in the formation of the vast ice-fields on the southern coast of Alaska from which magnificent glaciers descend to the sea. (Bull. Geol. Soc. Am., Vol. I., pp. 99–162.)

Geological News.—General.—Sir. Wm. Dawson has retained the name "Quebec Series" in his recently published hand-book, as the name for the Atlantic type of the lower member of the Ordovician, and as equivalent to Upper Calciferous and Chazy of the interior region of America. (*Canadian Record Science*, July, 1890.)—— Alexander Somervail offers the theory of "segregation" as an explanation of the banded structure of certain rocks in the Lizard District, England. By the the term segregation he means the separation of the unlike, and the union of like, minerals during the cooling of the common magna out of which the rocks are formed. (*Geol. Mag.*, Nov., 1890.)——Henry Hicks is of the opinion that the pre-Cambrian rocks of Britain contain evidences of successive periods of elevation

and depression, and probably of volcanic activity. He thinks also that the tendency of the evidence is to show that some granitoid rocks, such as those classed in Wales under the name Dimetian, are among the very oldest of the pre-Cambrian rocks which are now found exposed, and that some quartzites, porcellanites, and schists occupy an intermediate position in point of age between these granitoid rocks and the Pebidian series. (*Geol. Mag.*, Nov., 1890.)

MINERALOGY AND PETROGRAPHY.[1]

Petrographical News.—Mount Aviólo, in the southern Alps, consists in part of tonalite and in part of a quartz-mica-diorite, both of which intersect a series of crystalline schists, in which contact alteration has been effected. The tonalite is the rock so well known as comprising a large part of the Adamello group of the Alps. It is essentially a hornblendic quartz-mica-diorite. A garnetiferous variety is described by Salomon [2] as an endomorphous contact product. It is characterized by the possession of plagioclase zonally developed, with the most acid zones on the exterior. The extinction of crystals varies as much as 30°, being by this much greater in the nucleus than in the peripheral portions. The quartz-mica-diorite forms a boss only two kilometers distant from that of the tonalite, but it is regarded by the author as having no genetical relation with the latter. These two masses of eruptives are surrounded by two series of schists: a younger series including phyllites and epidote-amphibolites, and an older one embracing gneiss and mica-schists. The former are in contact with the diorite, by which they have been changed into rocks composed essentially of quartz, muscovite, biotite, chlorite, and andalusite, of which the biotite and andalusite are new products. Corundum, tourmaline, sillimanite, and zircon are also new products, but are present only in small quantity. A cordierite-biotite rock, consisting of these minerals together with quartz, was found as an inclusion in the diorite. According to the degree of alteration effected in them the rocks are separated into two zones: an outer one, the zone of the ilmenite-frucht-schiefer, in which the phyllites have suffered merely the change of their chlorite into biotite, and an inner zone, in which andalusite is an important constituent. The schists around the tonalite belong to the older series of gneiss and mica-schists. These have been

[1] Edited by Dr. W. S. Bayley, Colby University, Waterville, Me.

[2] *Zeits. d. deutsch. geol. Ges.*, XLII., 1890, p. 450.